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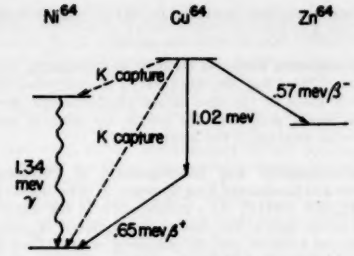


FIG. 1. Decay scheme of $Cu^{64}$.

The decay schemes used are shown in Figs. 1 and 2 below. The ratio $N_\gamma/N_{\beta^+}$ for $Cu^{64}$ is taken to be 0.025.[2] The number of 0.19-Mev $\gamma$-rays per disintegration of $Fe^{59}$ is taken as 0.025.[3] The number of 0.27-Mev $\beta$-rays was measured to be 0.48 per disintegration; the number of 0.46-Mev $\beta$-rays was 0.52 per disintegration.

The measurements yield the values for $\alpha_K$ given in Table I. Further experiments are planned to remeasure these quantities.

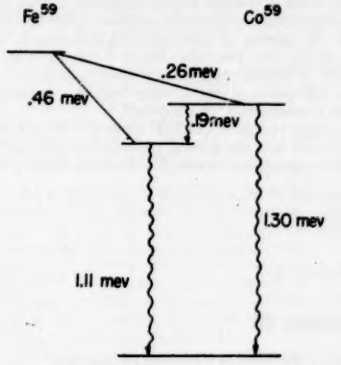


FIG. 2. Decay scheme of $Fe^{59}$.

The authors would like to thank the staff members at the Argonne and Oak Ridge piles for their cooperation in irradiating copper foils.

† This work was supported by the AEC.

[1] A. W. Tyler, Phys. Rev. **56**, 125 (1939).
[2] M. Deutsch, Phys. Rev. **72**, 729 (1947).
[3] Franz R. Metzger, Phys. Rev. **85**, 727 (1952).

## Lattice Imperfections of Diamond

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(Received April 29, 1952)

TO account for dielectric loss and non-uniformities in the electrical properties of diamond, Ahearn[1] has proposed that the lattice imperfections are not uniformly distributed, but form clusters and linear arrays, resulting in "pools of mobile charge" and "conducting channels." Measurements of the thermal conductivity of dielectric solids at low temperatures give information on the spatial grouping of individual imperfections,[2,3] and recent measurements of Berman[4] of the thermal conductivity of a diamond give some support to Ahearn's hypothesis.

At temperatures below 30°K the thermal conductivity is given by

$$\kappa = \tfrac{1}{3}CvL, \tag{1}$$

where $C$ is the specific heat, $v$ the velocity of the transverse elastic waves and $L$ a length of the order of the shortest linear dimension of the specimen. This corresponds to resistance due to the limitation of the phonon free path by the external boundaries. At temperatures above 100°K the conductivity fits

$$\begin{aligned} \kappa &\propto Te^{\theta/2T} \quad \text{for} \quad T \lesssim \theta/6, \\ &\propto 1/T \quad \text{for} \quad T > \theta/6, \end{aligned} \tag{2}$$

where $\theta$, the Debye temperature, is about 1840°K, which suggests that the major contribution to the resistance comes from "Umklapp"—processes, that is from interactions between phonons in which the total wave vector is changed by an inverse lattice vector. Between 30°K and 100°K the interaction varies only weakly with temperature.

It can be shown by using the exact formulas of the general theory of thermal conduction,[3] or by using the "cut-off approximation," that the observed conductivity in this temperature interval cannot be described by a gradual transition from boundary to Umklapp resistance, but that another scattering process predominates at these temperatures. This must be ascribed to structural imperfections, which are in all probability "frozen in" at these low temperatures, so that the temperature dependence of this additional resistance depends only on the variation with phonon-frequency of the scattering cross section.

The additional resistance is more or less independent of temperature, so that the scattering cross section varies as the cube of the frequency for frequencies between $30k/h \sim 6.5\times10^{11}$ and $100k/h \sim 2\times10^{12}$, which correspond to wavelengths between 60 and 20 interatomic distances.

Two interpretations are possible: either the imperfections form linear arrays of length large and diameter small compared with the above wavelengths (these may be dislocations), or they form clusters, whose diameters are of the same order as those wavelengths. The latter case would correspond to Ahearn's "pools of mobile charge." Their concentration would have to be about $10^5$ per $cm^3$ to account for the magnitude of the thermal resistance.

Thus there is some support for Ahearn's hypothesis. It would be interesting to see whether significant differences in the thermal conductivity between 30°K and 100°K would be found if specimens of different dielectric loss and breakdown resistance were studied.

[1] A. J. Ahearn, Phys. Rev. **84**, 798 (1951).
[2] Berman, Klemens, Simon, and Fry, Nature **166**, 277 (1950).
[3] P. G. Klemens, Proc. Roy. Soc. (London) **A208**, 108 (1951).
[4] Berman, Simon, and Wilks, Nature **168**, 277 (1951).

# Errata

**Nuclear Magnetic Moment and *j-j* Coupling Shell Model,** MASATAKA MIZUSHIMA AND MINORU UMEZAWA [Phys. Rev. **85**, 37 (1952)]. In Table III, the value of $\mu_{\text{calc}}$ for $Cl^{35}$ in the $T=\frac{1}{2}$ state should be 0.26, instead of $-0.48$. The authors wish to thank Professor M. Goeppert-Mayer for checking our results.

**Microwave Spectrum and Molecular Constants of Hydrogen Cyanide,** JAMES W. SIMMONS, WALLACE E. ANDERSON, AND WALTER GORDY [Phys. Rev. **77**, 77 (1950)]. In the paper of the above title a mistake of exactly 30 Mc was made in all frequency measurements of $HC^{13}N^{14}$ and of $HC^{15}N^{14}$. This resulted from an incorrect identification of the standard frequency markers. The 30 Mc are to be added to the frequencies. The corrected $B_0$ value for $HC^{13}N^{14}$ is $43169.83\pm0.15$ Mc.

In the remeasurement a somewhat better accuracy was obtained for the $HC^{13}N^{14}$ lines; the new $B_0$ value is 44315.97 ±0.10 Mc (with the same $D_J$ value as was used previously). The frequencies for the deuterated isotopic forms are correct as given, but a small numerical error was detected in the structural calculations. With these corrections, the interatomic distances are determined as follows:

| Molecular pair used | CH or CD distance ($10^{-8}$ cm) | CN distance ($10^{-8}$ cm) |
|---|---|---|
| $DC^{13}N^{14}-DC^{13}N^{14}$ | 1.0658 | 1.1555 |
| $HC^{13}N^{14}-HC^{13}N^{14}$ | 1.0674 | 1.1557 |
| $DC^{13}N^{14}-HC^{13}N^{14}$ | 1.0625 | 1.1566 |
| $DC^{13}N^{14}-HC^{13}N^{14}$ | 1.0623 | 1.1567 |
| $HC^{13}N^{14}-DC^{13}N^{14}$ | 1.0624 | 1.1563 |
| $HC^{13}N^{14}-DC^{13}N^{14}$ | 1.0619 | 1.1568 |
| | Av. 1.0637 ±0.004 | 1.1563 ±0.001 |

The average values for the two interatomic distances are very close to the original values quoted. However, the spread in the values obtained with the different isotopic combinations is significantly narrowed. As a result, a much smaller probable error in the determination of the interatomic distances is indicated.

We are indebted to Dr. A. E. Douglas, of the National Research Council of Canada, and to Professor D. H. Rank, of Pennsylvania State College, for calling to our attention the probability of the mistake in frequencies. We are indebted to Dr. Ralph Trambarulo and to Mr. W. C. King for assisting with the remeasurement and the recalculation.

**Multiple Events Produced in Hydrogen by Very High Energy Cosmic-Ray Particles at an Altitude of 90,000 Feet,** M. L. VIDALE AND MARCEL SCHEIN [Phys. Rev. **84**, 593 (1951)]. The first column of Table I, under the heading "Number of counters activated in tray *T*" should read **2, 3,** instead of ⩾ 2, ⩾ 3.

**Thermoelectric Power of Carbons and Graphite,** EGON E. LOEBNER [Phys. Rev. **84**, 153 (1951)]. A regrettable mistake has been made in the sign of the thermoelectric power of carbons *versus* platinum. All values are positive and not negative as reported in the letter.

**Semiconductivity and Diamagnetism of Polycrystalline Graphite and Condensed Ring Systems,** S. MROZOWSKI [Phys. Rev. **85**, 609 (1952)]. As a consequence of the unfortunate mixup in the sign of the thermoelectric power of carbons in the work of Loebner (see the preceding erratum) the general picture of the electronic processes in carbons has to be inverted, that is, all through the paper "excess electrons" should read "excess holes" ("traps" instead of "donors"). Excess holes are created in the filled band by trapping of resonance electrons on surface sites. The nature of these surface traps can be described in the following way (the following should be substituted for lines 15 to 1 from the bottom on p. 617 in the right-hand column): "When the atom attached to the peripheral carbon is removed, the carbon orbital corresponding to the free valence can now accommodate two electrons. A resonance electron jumps into the planar valence orbital, if the activation energy necessary for the change of the configuration happens to be supplied by the heat vibration; due to the pairing of spins this configuration is the more stable of the two. The hole created in the band of resonace electrons is almost free; a very small amount $\epsilon$ of kinetic energy will suffice to tear it away from the negative ion left behind. Consequently, this hole will. . . ."

The negative sign of the Hall coefficient for baked carbons does fit well into the general picture; this point will be discussed in subsequent publications from our laboratory.

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**Soft Radiations from $Am^{241}$,** J. K. BELING, J. O. NEWTON, AND B. ROSE [Phys. Rev. **86**, 797 (1952)]. Because of a computational error, the values in Table I are incorrect. The correct values are as follows:

| Radiation energy (kev) | 59.7 | 26.3 | 20.9 | 17.3 | 13.5 |
|---|---|---|---|---|---|
| Relative intensity | 1 | $0.069 \pm 0.007$ | $0.155 \pm 0.016$ | $0.56 \pm 0.04$ | $0.32 \pm 0.04$ |

**Helium II Transfer Rates on Lucite and Perspex Surfaces,** B. S. CHANDRASEKHAR [Phys. Rev. **86**, 414 (1952)]. The units along the $y$ axis of the graph should be $10^{-8}$ cm³/cm sec.

**Nuclear Matrix Elements in the Theory of Beta-Decay,** HENRY BRYSK [Phys. Rev. **86**, 996 (1952)]. The fifth sentence of the first paragraph on p. 1000, reading "These matrix elements correspond to the spin-orbit coupling implicit in the Dirac equation; for the larger empirical spin-orbit coupling (from shell breaks), they would presumably be considerably larger," was misplaced. It refers to the $l$-forbidden transitions, and should be in the next paragraph.

**Low Energy γ-Transitions in Some Rare Earth Isotopes,** J. W. MIHELICH AND E. L. CHURCH [Phys. Rev. **85**, 690 (1952)]. In Table I, the $(K/L)_{exp}$ value for $_{68}Er_{98}^{166}(Ho^{166}\ 27\ hr)$ should be $0.07^{+0.2}_{-0.02}$.

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